A General River and Reservoir Modeling Tool

Developed at the University of Colorado Center for Advanced Decision Support for Water and Environmental Systems (CU-CADSWES)
1993 to present through collaborative research and development with
Tennessee Valley Authority
U.S. Bureau of Reclamation
U.S. Army Corps of Engineers

University of Colorado - CADSWES

CENTER FOR ADVANCED DECISION SUPPORT FOR WATER AND ENVIRONMENTAL SYSTEMS

MISSION STATEMENT

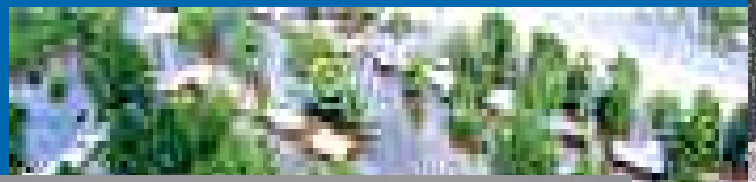
To research, design, prototype and develop integrated decision support systems to help solve real world water resources and environmental problems,

and

to provide technology transfer and user support to the water management agencies and others in the use of these tools.

RiverWare

RiverWare models the many objectives of a river/reservoir system…



naviga

hydropower

recreation

water quality

riparian habitat

RiverWare

For a range/variety of purposes

- Planning
  - Monthly to Annual timestep over many years
  - historical/stochastic inputs
- Mid-term forecasting
  - Daily, weekly or monthly timestep over months to years
  - Start with initial conditions; use seasonal forecasts, snowpack info, etc.
- Scheduling
  - Hourly, 6-hour, 12-hour or daily timestep over a few days to a few weeks
  - Schedule operations for today and next few days using weather forecasts
- Policy Evaluation (e.g. EIS)
  - Planning studies with variable operational policy sets
- Water Accounting
  - Model and Track Water Ownership for legal purposes; combine accounting with policy

RiverWare

History of RiverWare Development

1992-93	Requirements with *TVA, USBR*
1993-96	Initial Development of Simulation, RBS, Optimization, DMIs, MRM *TVA, Colorado R*
1997-98	New RBS, begin Water Accounting *Upper Rio Grande, San Juan, Yakima, Pecos*
1998	Available to Public through CU Tech Transfer
1999-2002	Water Accounting,Enhanced Analysis Window Port, new plotting Truckee, Upper Columbia
2002-04	COE Flood Control *Arkansas, LCRA, L.Neches*
Continuous enhancement of simulation methods, performance, analysis capabilities, and features	

Original/Ongoing Objectives of RiverWare Research & Development

- Use for a range of studies: operational scheduling, forecasting and planning
- Provide multiple solution methodologies (simulation, simulation with rules, and optimization)
- Operating policy expressed as data
- Easy to use – modelers are not software engineers
- Automatic Data Management Interface
- Extensible; can tailor to any basin
- Supported / maintained

RiverWare

Three Solution Approaches

1. Simulation

   models physical processes for a variety of input/output combinations (upstream/downstream; forward/backward in time)

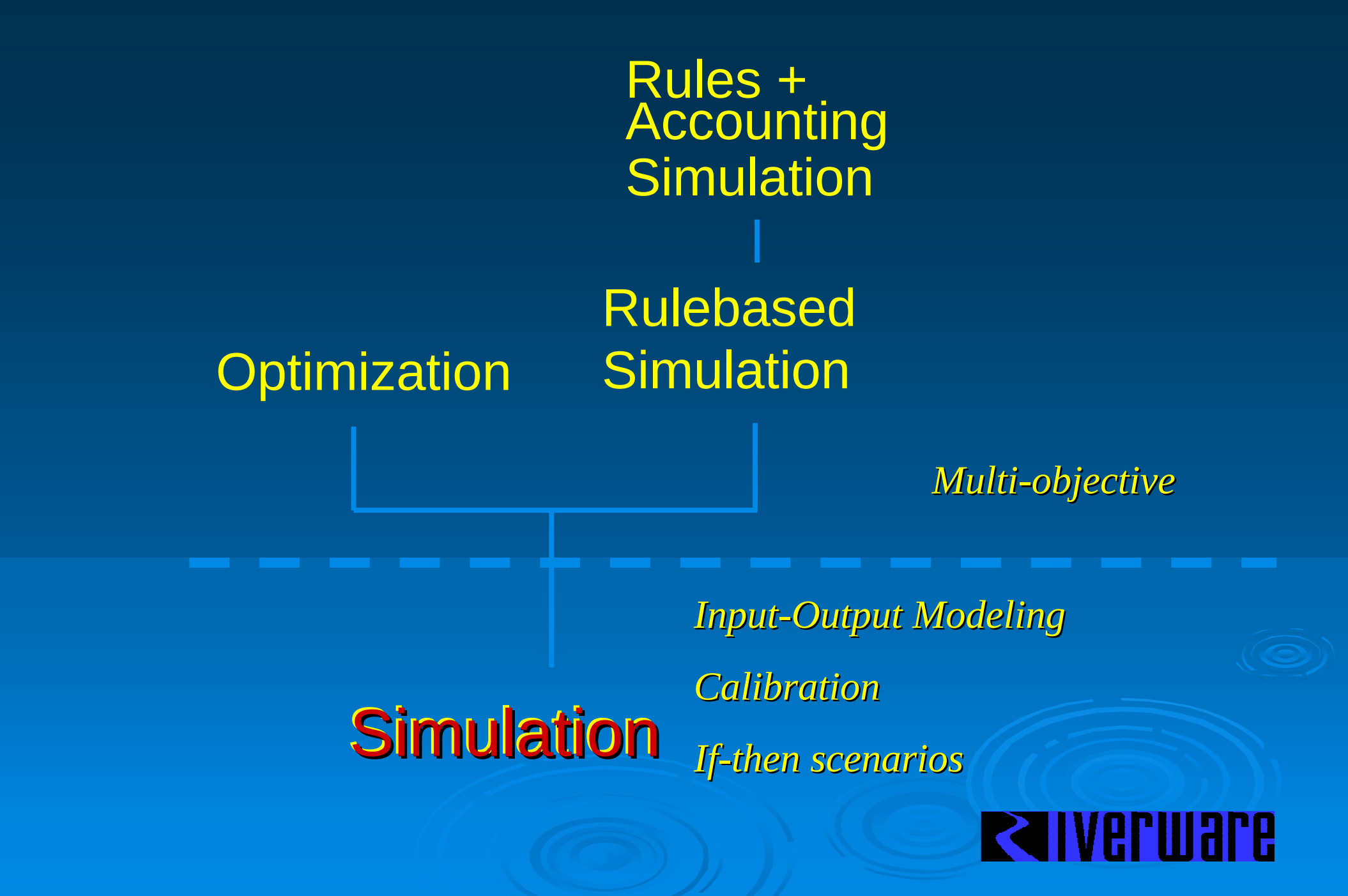
2. Rulebased Simulation

   simulation driven by user-specified operating rules (policy) expressed through an interpreted language

3. Optimization

   linear goal programming solution

RIVERWARE


Rules +
Accounting
Simulation
Rulebased
Simulation
Optimization
Multi-objective
Simulation
Input-Output Modeling
Calibration
If-then scenarios
RiverWare

Water Ownership, Water Accounting, Water Rights

- "Paper" Accounting
  - optional reconciliation
- Storage, Flow, Diversion Rights
- Exchanges, Loans, Rents, Carryover
- Accrual
- Spreadsheet Solution
- Mix with Rulebased Simulation
- Network Optimization (future development)

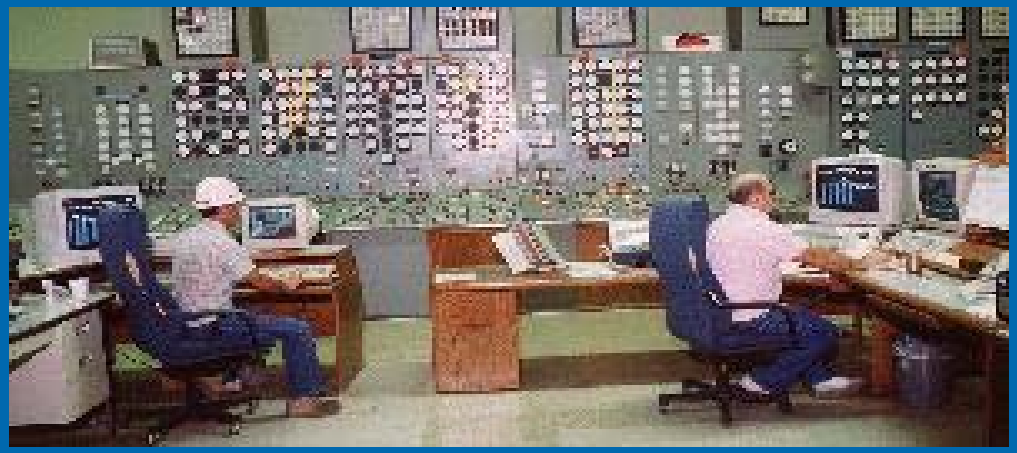
RiverWare

Water Quality

- Simple well-mixed Total Dissolved Solids (TDS)
- Dissolved Oxygen (DO), Temperature, TDS
  - 2-layer reservoir
  - coupled Reach Routing with Advection, Diffusion

RiverWare

Data Management Interface



- Import or export data from/to any external source (files, databases)
- Create external routines to tailor your applications
- Define the DMI and execute it from within the RiverWare user interface
- Extend or redefine start/stop time of the runs
- Group DMIs together for operational updates

RiverWare

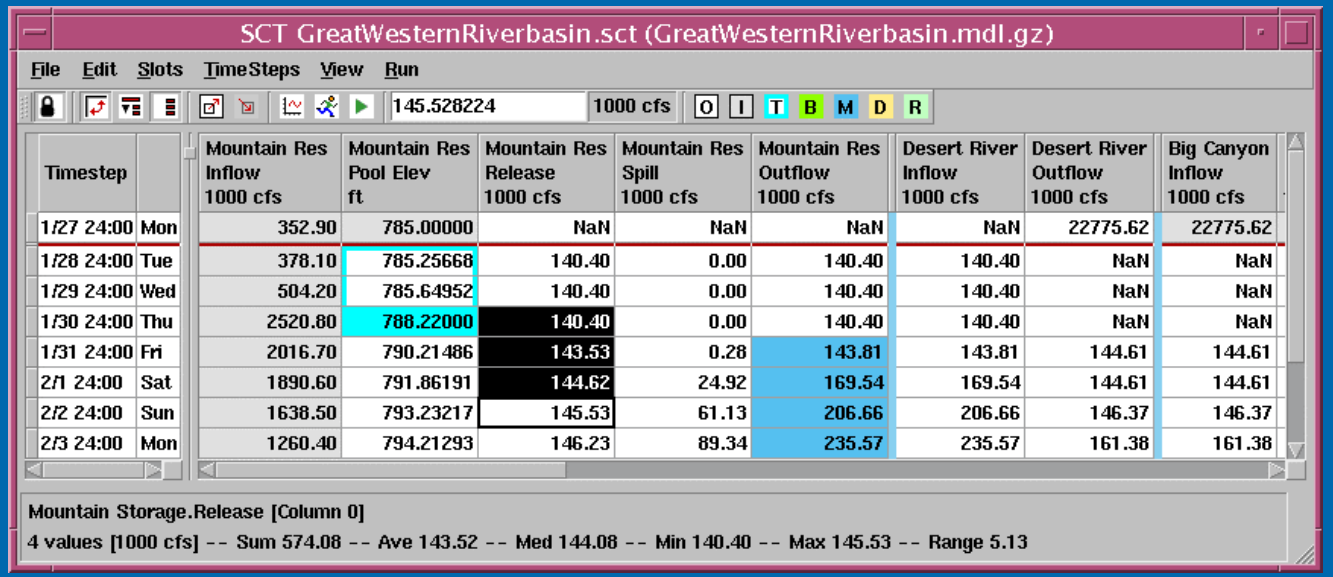
Current DMI applications….

- HDB (Reclamation's Oracle DB)
- DSS (used by many COE and non-COE users)
- Flat files
- other databases

Upcoming development
(as part of HEC/CWMS integration:
Direct linkage to DSS and to HDB

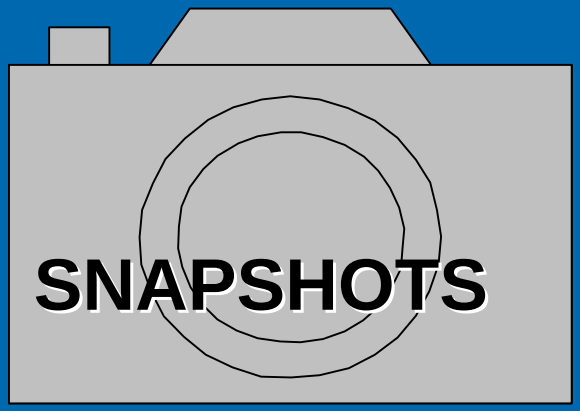
Many other Features

- SCT
- Diagnostics
- Analysis Features
- Output options
- Multiple Run Management
- GPAT

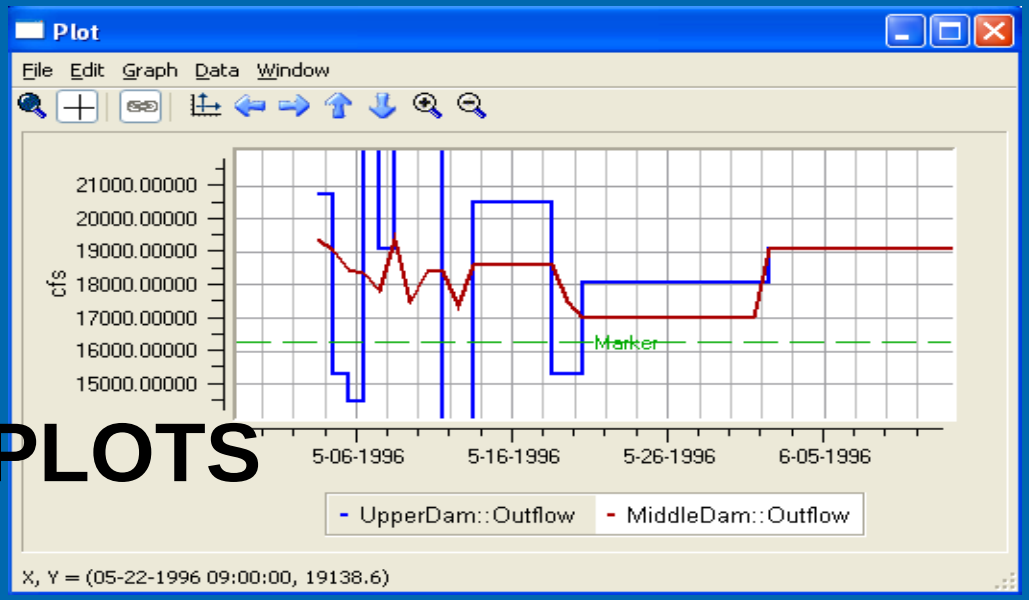


Timestep		Mountain Res Inflow 1000 cfs	Mountain Res Pool Elev ft	Mountain Res Release 1000 cfs	Mountain Res Spill 1000 cfs	Mountain Res Outflow 1000 cfs	Desert River Inflow 1000 cfs	Desert River Outflow 1000 cfs	Big Canyon Inflow 1000 cfs
1/27 24:00	Mon	352.90	785.00000	NaN	NaN	NaN	NaN	22775.62	22775.62
1/28 24:00	Tue	378.10	785.25668	140.40	0.00	140.40	140.40	NaN	NaN
1/29 24:00	Wed	504.20	785.64952	140.40	0.00	140.40	140.40	NaN	NaN
1/30 24:00	Thu	2520.80	788.22000	140.40	0.00	140.40	140.40	NaN	NaN
1/31 24:00	Fri	2016.70	790.21486	143.53	0.28	143.81	143.81	144.61	144.61
2/1 24:00	Sat	1890.60	791.86191	144.62	24.92	169.54	169.54	144.61	144.61
2/2 24:00	Sun	1638.50	793.23217	145.53	61.13	206.66	206.66	146.37	146.37
2/3 24:00	Mon	1260.40	794.21293	146.23	89.34	235.57	235.57	161.38	161.38

Additional Output Options



PLOTS



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Selected Applications of RiverWare

- Tennessee Valley Authority
- Colorado River – CRSS, 24-month study (USBR)
- Lower Colorado EIS (USBR and stakeholders)
- San Juan – daily operations, EIS (USBR, USGS, BIA, states, FWS)
- Yakima – planning model (USBR)
- Upper Rio Grande – URGWOM (USBR,COE, USGS, many others)
- Pecos – EIS (USBR, NMISC)
- Gunnison – policy analysis for environmental issues (USBR,NPS)
- Truckee River – accounting and daily operations (USBR, stakeholders)
- Umatilla – (USBR, BIA)
- Lower Colorado (Texas)
- Lower Neches
- Arkansas (COE SWD)
- Kansas R. (COE KC)

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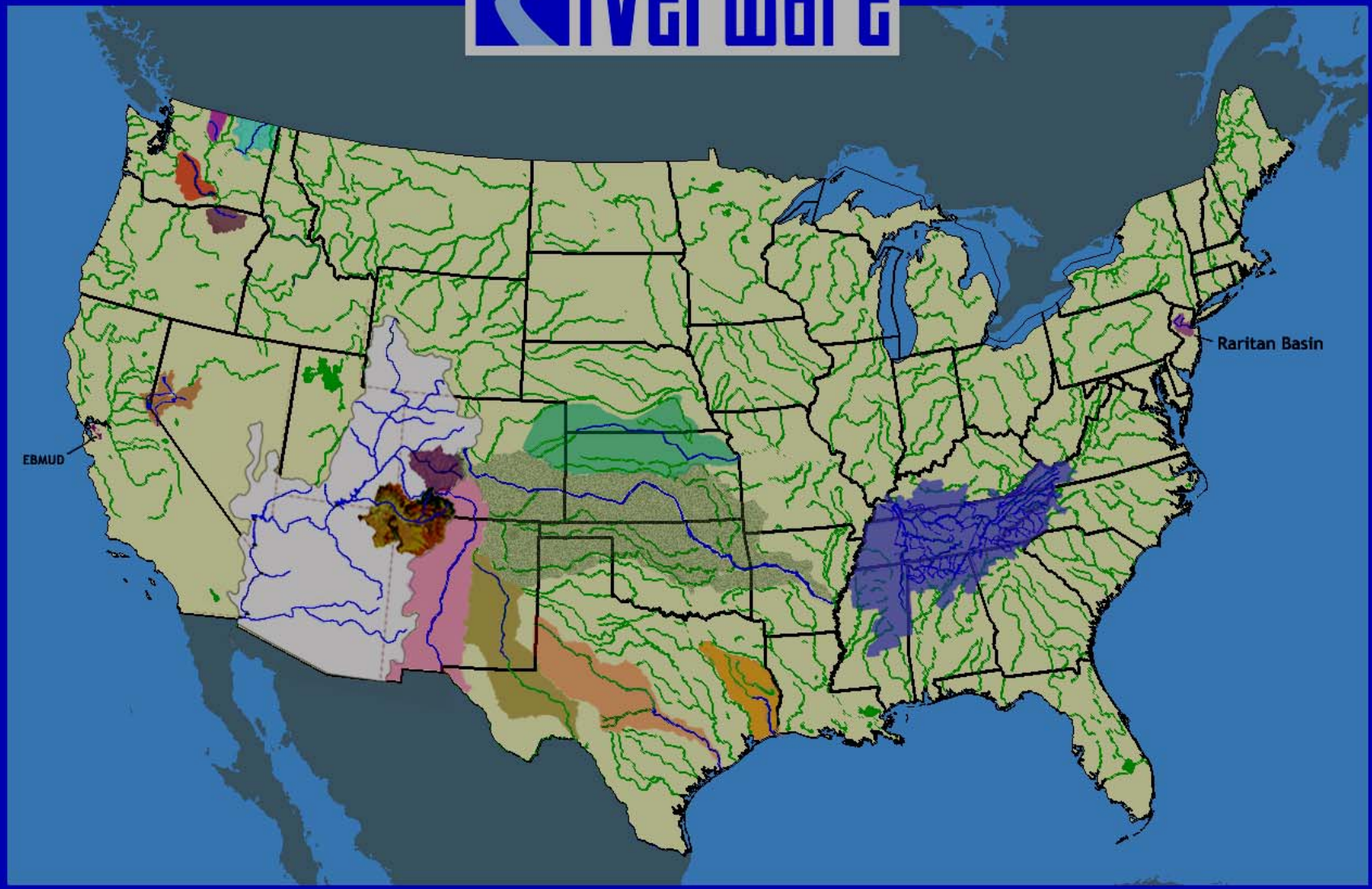

Software Quality Assurance

- Professional software development processes
- Requirements, Functional Specifications and Designs are documented
- Code is peer-reviewed
- Source control
- Regression testing
- Formal bug reporting and tracking
- Team of experienced, professional software developers as well as water resources engineers

RiverWare

Hardware Requirements

- UNIX - Sun Solaris 2.7-2.9
- Windows NT /Win2000/XP

Licensing

- Available through the University of Colorado

  via MOU between CU, TVA, USBR

- License fees contribute to software maintenance

Releases

- Two major releases per year/ patches as needed

Training & User Support

- Offered through CADSWES

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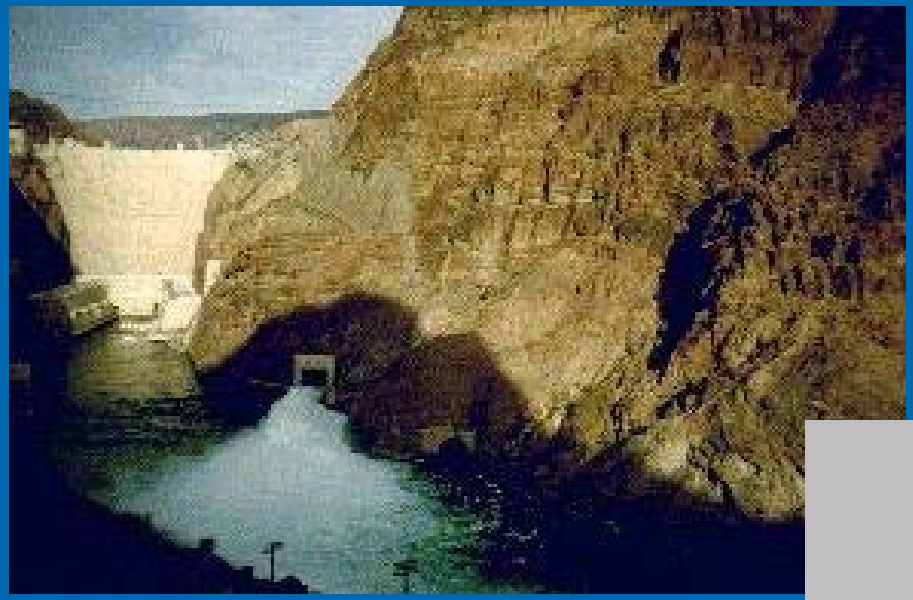

http://cadswes.colorado.edu/riverware

RiverWare